

VIBRATION WAVE DRIVING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

5 This invention relates to a vibration wave driving apparatus having an output shaft.

Related Background Art

10 Several vibration motors (vibration wave driving apparatuses) having output shafts are known. For example, as shown in Fig. 4 of the accompanying drawings, there is a motor disclosed in Japanese Patent Application Laid-Open No. 5-38170. This motor is such that piezoelectric elements 142 and 144 are disposed between metallic blocks 150 and 152 as hollow
15 cylindrical elastic members and the two metallic blocks 150 and 152 are coupled together into a vibration member 140 by a cylindrical coupling bolt 154 disposed on the inner peripheral side of these metallic blocks 150 and 152. On the other hand, a
20 motor housing (outer case) 170 is such that the cylindrical portion of the central portion of a motor forms a motor supporting portion and a bearing 172 is disposed in the motor supporting portion and supports an output shaft 134, and a ring-shaped flange portion
25 175 provided on the inner diametral portion of a coupling bolt 154 is fixed to the motor supporting portion and supports the vibration member 140.

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Also, a rotor portion 130 as a contact member is disposed on one side of the vibration member 140, and this rotor portion 130 is of a construction in which a spring 133 is disposed between a fixed rotor body
5 (disc) 132 and a support plate 136 in the direction of rotation of the output shaft 134, and the rotor body 132 is brought into pressure contact with the end surface of the metallic block 152 by the spring force of a spring 133.

10 ~~In the above-described example of the prior art,~~
however, the bearing is one and therefore, when a force is applied from a side to the output shaft, the output shaft is inclined with the aforementioned bearing as a fulcrum, and the rotor portion deviates
15 relative to the vibration member. As the result, the frictional contact state in a rotor contact surface 160 wherein the rotor body 132 contacts with the metallic block 152 becomes non-uniform, and there have arisen problems such as a reduction in the efficiency
20 of the motor, the occurrence of noise and the wear of the contact surface (a reduction in the life of the motor).

SUMMARY OF THE INVENTION

25 ~~One aspect of this invention is to provide a vibration type driving apparatus wherein a vibration member is supported in a case thereof by a support~~

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~~member and an output shaft is supported by the~~
bearings at the opposite end portions of the case, and
the output shaft is extended through a through-hole in
the axial center portions of the vibration member and
5 a rotating member, and the through-hole of the
vibration member is used as a sliding bearing for the
output shaft, whereby which can stably drive even if
extraneous forces act on the output shaft from various
directions.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of a vibration
type driving apparatus according to a first embodiment
of the present invention.

15 Fig. 2 is a cross-sectional view of a vibration
type driving apparatus according to a second
embodiment of the present invention.

Fig. 3 is a cross-sectional view of a vibration
type driving apparatus according to a third embodiment
20 of the present invention.

Fig. 4 is a cross-sectional view of a vibration
type driving apparatus according to the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 [First Embodiment]

Fig. 1 shows a first embodiment of the present
invention.

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In a vibration wave driving apparatus according to this embodiment, a circular ring-shaped piezoelectric element 4 as an electro-mechanical energy conversion element and a vibration member supporting member 3 formed by a thin plate of a metal or the like are sandwiched between bar-like hollow metallic members 5 and 6 as two elastic members, and these metallic members 5 and 6 are held and fixed by a hollow bolt 1 and a nut 7 made of a metal which are fastening members to thereby constitute a vibration member.

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The vibration member in the present embodiment combines two bending vibrations and forms circular or elliptical motion on a driving surface, and the driving principle thereof is described in Japanese Patent Application Laid-Open No. 3-011981, etc. and is already well known and therefore need not be described. The vibration member may be one which combines not only two bending vibrations, but also, for example, a torsional vibration and a longitudinal vibration. There is a hole in the axial center portion of the vibration member, and the vibration wave driving apparatus of the present embodiment need be a vibration wave driving apparatus of a form in which an output shaft 2 extends through this hole.

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~~In the vibration wave driving apparatus of the present embodiment, a rotary member 8 is disposed on~~

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~~one side of the vibration member, and a cylindrical~~
frictional sliding member 8a is fixed to the outer
peripheral portion of the rotary member 8 and the fore
end portion of the frictional sliding member 8a which
5 is adjacent to this rotary member is adapted to
contact with a frictional sliding member 5a on the
vibration member side which is provided on the outer
peripheral end portion of the end surface of the
metallic member 5 constituting the vibration member.
10 The rotary member 8 is fitted to the outer diametral
portion of a pressing spring 9 which is a hellevill
spring having its coaxiality and inclination with
respect to the output shaft 2 regulated by a caulking
member 12, and the sliding member 8a of the rotary
15 member 8 and the frictional sliding member 5a on the
vibration member side are adapted to be brought into
pressure contact with each other by the spring force
of the pressure spring 9.

The vibration member in the present embodiment is
20 constructed with the vibration member supporting
member 3 sandwiched and fixed simultaneously with the
piezoelectric element 4. The vibration member
supporting member is disc-shaped, and the outer
peripheral portion thereof is joined to the
25 confronting surfaces of the case portions 15 and 16 of
an external case of a two-division construction.
~~This joint is carried out by electric resistance~~

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~~welding, laser welding, adhesion by an adhesive agent, or brazing.~~

~~The role of the vibration member supporting member 3 is to support the vibration member, but if the vibration member supporting member is too thick and too great in rigidity, a vibration generated by the vibration member is transmitted to the aforementioned case, and vibration energy of high efficiency comes to be not generated. Therefore, the vibration member supporting member 3 has suitable flexibility. Because of it, the vibration member has its spatial position not firmly determined relative to the external case, and becomes inclined or eccentric.~~

~~As the result, the vibration of the vibration member is not efficiently transmitted to the frictional sliding member 8a of the rotary member 8 and the following problems arise.~~

1. Creation of motor noise
2. Reduction in motor life due to the localized wear of the frictional sliding member
3. Reduction in motor efficiency

In order to prevent these evils, in the present embodiment, the through-hole 1a of the hollow bolt 1 plays the role of a bearing supporting the output shaft 2.

In the present embodiment, a sintered metallic oil-containing bearing 11 is caulked to one external

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case portion 15, and on the opposite side, a ball bearing 10 is forced into the other external case 16. The output shaft 2 is supported by those two bearings 10 and 11.

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5 Further, ~~two snap rings 17 are disposed so as to sandwich the ball bearing 10 therebetween from the opposite sides and therefore, the output shaft 2 has its spatial position determined relative to the aforementioned external case. That is, the position of the output shaft 2 is first determined relative to the external case, and the through-hole 1a acts as a bearing relative to the output shaft 2 and thus, the position of the vibration member is determined.~~

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15 On the other hand, the rotary member 8 is fitted to the outer diametral portion of the pressing spring 9 having its coaxiality and inclination with respect to the output shaft 2 regulated by the caulking member 12. Consequently, the rotary member 8 has its spatial position substantially determined relative to the
20 output shaft 2.

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25 ~~Thus, the vibration member and the rotary member 8 have their positions determined with the output shaft 2 as the reference and therefore, the frictional sliding member 8a on the rotary member side and the frictional sliding member 5a on the vibration member side become capable of stably contacting with each other.~~

In the present embodiment, vibration preventing rubber 23 is interposed between the rotary member 8 and the pressing spring 9, whereby the vibration of the rotary member 8 can be prevented from propagating to the output shaft 2, and the vibration preventing rubber 23 also performs the role of joining the rotary member 8 and the pressing spring 9 together.

~~Near the ball bearing 10, a rotary plate 13 which is a part of an encoder for detecting the rotated position is fixed to the output shaft 2. The rotary plate 13 is formed with a number of holes in radial directions, and the rotation of the rotary plate is counted by the interception and passage of light from a photointerrupter 14 fixed to the inner side of the case 16 to thereby detect the position. If the photointerrupter 14 is one of a fiber type which can obtain thin rays of light, the resolving power will be improved and the positioning accuracy will also be heightened and therefore, it is more desirable.~~

~~In the present embodiment, a sensor of a light detecting type is used as the photointerrupter, but a potentiometer or the like for detecting the rotated position by a vibration in an electrical resistance value may be contained in the case.~~

[Second Embodiment]

Fig. 2 shows a second embodiment of the present invention.

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~~A vibration member in this embodiment, unlike~~
that in the first embodiment, does not use a hollow
bolt which is a fastening member. Metallic members 5
and 6 as two elastic members, a vibration member
5 supporting member 3 and a piezoelectric element 4 are
adhesively secured and coupled together by an adhesive
agent.

In the present embodiment, frictional sliding
portions are provided on the opposite ends of the
10 vibration member, and two rotary members 8 are also
provided. Thereby, usually as compared with a motor
having a rotary member, the created torque becomes
double. Also, a large-diametered hole portion is
formed in the axis of each rotary member 8 from the
15 outer end side thereof, and the inner end portion side
thereof is made small in diameter, and a pressing coil
spring 9 is disposed in this large-diametered hole
portion so as not to slip off.

Also, a rotation stop 12 is mounted in the
20 aforescribed large-diametered hole portion on the
outer end portion side of each rotary member 8, and a
spline is formed in the outer periphery of the
rotation stop 12 and is fitted to the rotary member 8.
The rotation stop 12 is inserted into the inner spline
25 portion of the rotary member 8 while being forced onto
the output shaft 2 and compressing the pressing spring
9. ~~The rotary members 8 have the rotation restrained~~

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~~relative to the rotation steps 12, but can freely~~
slide in the axial direction thereof. Consequently,
only the rotational forces of the rotary members 8 can
be transmitted to the output shaft 2.

5 Flanged sliding bearings 18 are provided on the
inner diametral end portions of the metallic members 5
and 6 as elastic members. In the present embodiment,
as the bearing portions of the sliding bearing 18, use
is made of bearing portions made of polyacetal, but
10 depending on the temperature at which the motor is
used, a material having good heat resistance such as
Nylon, Teflon or PPS is preferable in some cases.

In the present embodiment, the sliding bearings
18 are fixed to the outer sides of the metallic
15 members 5 and 6 as elastic members, and the output
shaft 2 is rotated relative to the sliding bearings
18, but the output shaft 2 and the sliding bearings 18
may be fixed and the sliding bearings 18 and the
metallic members 5 and 6 may be made rotatable
20 relative to each other. In this case, the output
shaft 2 may be covered with a heat-contracting tube
made of resin or the output shaft 2 may be coated with
resin such as Teflon. Further, if oil is contained in
the interior of the resin, the output shaft 2 can be
25 rotated more smoothly and this is desirable.

~~This oil does not flow out to the outside and~~

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therefore, ~~there is no fear that the oil goes round to~~
the frictional sliding portion of the vibration member
or the rotary member. Also, vibration leakage is
preferably little if the sliding bearings 18 are
5 disposed at positions which are the nodes of the
vibration of the vibration member. The sliding
bearings 18 may be made of an oil-containing sintered
metal, but may more desirably be made of resin because
in the case of such metal, noise is liable to occur
10 ~~due to the vibration of the vibration member.~~

The vibration member and the rotary member are
assembled together in advance outside the case with
the rotation stops 12 forced onto the output shaft 2,
and the assembly is inserted into an external case 30
15 molded by press drawing.

The vibration member supporting member 3 has
three radially outwardly extending legs, and as shown
in Fig. 2, the tip end portion of each leg is bent and
therefore, the insertion of the vibration member
20 supporting member into the external case 30 can be
done smoothly. When the rotation stop 12 strikes
against a sliding bearing 11 of a sliding bearing
type, the vibration member is rotated relative to the
external case about the output shaft, and the three
25 legs of the vibration member supporting member 3 are
fitted into three holes 30a formed in the external
case 30 by the utilization of their elastic forces of

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restitution.

The number of the legs of the vibration member supporting member is not limited to three, but may be one. The role of the supporting member is to prevent the vibration of the vibration member from being transmitted to the case, and resist a torsional force applied to the vibration member. The displacement of the vibration member near the center thereof is minute and substantially at a right angle with respect to the output shaft and therefore, the supporting member is designed to be soft in this direction and be rigid in the direction of torsion of the vibration member.

~~A lid member 31 is fitted to the external case 30, and at this time, a spacer 19 made of resin is put onto the output shaft 2. By virtue of this spacer 19, any unreasonable force is not applied to the vibration member supporting member 3, etc. even when an axial force is applied to the output shaft 2.~~

Lastly, the vibration member supporting member 3 was soldered to the hole 30a of the external case 30, and the external case 30 and the lid member 31 were joined together by an adhesive agent. In these cases, the joint may be course be done by welding or the like. In the present embodiment, the rotary members 8 are brought into pressure contact with frictional sliding members 5a on the vibration member side by the pressing springs 9, but the reaction forces thereof

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~~are received by the two rotation stops 12 forced onto the output shaft 2 and therefore, there is not any friction loss by forces axially created in the bearings 11.~~

5 While in the above-described first embodiment, the reaction force created by the pressing spring 9 being pressed is received by the ball bearing 10 of the ball bearing type through the snap ring 17 lying outside the external case, the ball bearing need not
10 be used in the present second embodiment.

 Also, frictional sliding members 8a on the rotary member side have their portions corresponding to sliding portions bent. This is means for widening the frictionally sliding area, reducing the surface
15 pressure of a frictionally sliding surface, decreasing the wear of a frictional material, and lengthening the life of the motor.

[Third Embodiment]

 Fig. 3 shows a third embodiment of the present
20 invention.

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~~This third embodiment, like the second embodiment, is of a type in which rotary members 8 are provided on the opposite end portions of a vibration member, and a sliding bearing 22 comprised of a
25 sliding bearing similar to the sliding bearing 18 in the second embodiment is provided in the hole portion of the small-diametered portion side on the inner end~~

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~~side of each rotary member 8. This sliding bearing 22~~
is made of resin and is forced into the aforescribed
bore of each rotary member 8. By virtue of this
sliding bearing 22, each rotary member 8 has become
5 rotatable without being eccentric relative to the
output shaft 2. Therefore, the irregularity of the
rotation of the motor has become little.

Also, in the present embodiment, sliding bearing
32 of a sliding bearing type are forced into the
10 ~~opposite ends of the bore portion of a hollow belt 1.~~

A vibration member supporting member 3 is
interposed and fixed between external case portions 15
and 21.

Besides a piezoelectric element 4 and the
15 vibration member supporting member 3, a flexible
printed substrate 20 is held and fixed between two
elastic members 5 and 6, and extends outwardly along
the inner surfaces of the external case portions 15
and 21. This flexible printed substrate 20 is used as
20 wiring for the supply of an electric current to the
piezoelectric element 4, the supply of an electric
current produced by a voltage produced in the
piezoelectric element, and further an electric current
to a rotated position detecting element like a
25 potentiometer.

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~~As described above, according to the present
invention, the positional relation of the output shaft~~

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~~is determined relative to the through-hole of the~~
vibration member and therefore, the vibration member
is not inclined with respect to the output shaft, and
even if a sideways force is applied to the output
5 shaft, the contact state of the frictionally sliding
surface is stabilized and therefore, the vibration
wave driving apparatus of the present invention has
become a vibration wave driving apparatus of high
efficiency and long life.

10 The bearing is also provided in the through-hole
of the rotary member, whereby when the rotary member
is rotated, the eccentricity relative to the axis of
the vibration member is also decreased and therefore,
the motor of the present invention has become a more
15 excellent motor. Further, the bearing surface of the
sliding bearing or the surface of the output shaft
supported by the bearing surface is made of resin,
~~whereby the occurrence of noise has been suppressed.~~

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